(Final Report)

Report on a System Architecture Workshop

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Submitted by

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14. ABSTRACT

System architecture has emerged as one of the most important areas of research for the Air Force. Many past system failures or problems can be attributed to improper system architectures or even no architecture at all. It is very critical to identify a set of important research topics in this area so that researchers and funding agencies can focus their attention to these topics to make the research investments most effective and to produce the research results that can benefit the Air Force most.

This report summarized the results of a system architecture workshop which was held in New Orleans in January 2004. It identified a variety of research issues and topics in system architecture We believe investments on these research topics will great enhance Air Force's capabilities in acquisition, design, and implementation of future generations of systems.

15. SUBJECT TERMS

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2. Objective

A system consists of components, which could be systems themselves. Sometimes, different ways of linking the components together may produce systems with different behavior and properties. In the past, many projects were delayed or designed incorrectly because of lack of understanding of system architecture. In building large-scale systems (information systems and non-information systems) in the past twenty years, mo organizations (no matter they are in the military/government domain or in the private domains) became recognized the importance of system architecture. The objective of the project is to organize a workshop to brainstorm the important issues in system architecture.

3. Status of the Effort

The project has completed, and we have identified a variety of research issues in system architecture.

4. Accomplishments and New Findings: Research Topics Identified and recommended

Some of the highlights of the Air Force-LSU New Orleans System Architecture workshop (January 2004) are:

- Introductions
  Dr Northrup Fowler III, Chief Scientist, AFRL/IF
  Mr John Graniero, Director Information Institute
  Dr Robert Herkholtz, AFOSR

- Keynote "Challenges in DOD Architectures"
  Dr. Alex Levis USAF Chief Scientist
- Keynote "Issues in System Architecture"
  Joel Moses, Professor, MIT
- Keynote "Building Architecture vs. Information System Architecture"
  Ugo Gagliardi, Golden McKay Professor, Harvard
- Keynote "System Architecture and disaster engineering"
  Dr. C.V. Ramamoorthy, U.C. Berkley
- Keynote "Mathematical Models for System Architecture"
  Dr Peter Chen, Louisiana State University

Other Speakers Included: Tim Busch, Dwayne Perry, and Lee Waggonals

The New Orleans System Architecture Workshop identified promising areas of research which could help define both current and next generation DoD System Architectures. The workshop results can be summarize as a set of innovative research approaches to describe system architectures, innovative ways to build new architectures and innovative ways for the DoD to develop and share architectures. Success in this area encompasses ways to challenge the DoD services to work together to achieve enduring, flexible and scalable system architectures. A key finding was to develop innovative ways to address the development of rigid system architectures over time.

There is a need for development of seamless flow from architecture (static) analysis (for things that can be proved) to test (dynamic analysis) for characteristics dependent on run time context (what is minimum necessary features to enable these analyses). Currently overall architecture frameworks do not really addres time. Systems are viewed in terms of separate builds/versions without good linkages explaining transformations/changes. Support for evolution is crucial to system design. In order to consider temporal aspects, evolution of architecture requires explicit consideration of time. System changes are very fine grain and rapid with the need for evolution as continuous process rather than a series of snap shots particularly for self modifying and learning systems.

The continuous inclusion of time is theoretical and a key requirement is for architecture community to address the importance of timing. When an architecture evaluation is performed, temporal aspects are required to perform evaluation. Problem is how to develop temporal metrics without introducing failure?

Specific research needs include:

- Languages, libraries, and tools to support evolution of systems
- Tools to analyze the impact of a change
- Storyboarding techniques to explain the system over time
- Representation/tools for describing dynamic architectures of independent cooperating objects/agents.
- Slicing tools, constraint propagation techniques

Other research topics identified in the workshop include

- Architecture Analysis/Assessment Techniques/Tools
- Conceptual Architecture (Function/Activity, Metadata, Interaction)
- Object database and data mining concepts
- Architecture repository.
- System development integration issues .
- Architecture Query language
- Vocabulary of System Architecture including Calculus of System Architecture
- Quantification of components of System Architectures
- Dynamic Flexibility of architecture to changing requirements
- Structure architecture to be able to capture new data
- What are essential elements of system architecture design?
- Open Source Architecture for Selected AF Systems
- Component Compilers
- Definition of metrics at different levels of the architecture
- Representation of human behavior in both the architecture and the system?
- Simulating architecture(s)
- Facilitate reuse of infrastructure components across differing architectures
- Composability and the "goodness" of the composition of models

5. Personnel Supported:
Peter Chen (faculty) and student assistants.

3. Publications
3. 1. Journal Publications

Peter Chen and Guoli Ding, "The Best Expert vs. the Smartest Algorithm", Theoretical Computer Science, Vo 324, No. 2-3, (2004), pp. 361-380.

S. Seiden, P. Chen, R. Lax, J. Chen, G. Ding , "New Bounds for Randomized Busing", Theoretical Computer Science, Vol. 332, No. 1-3, (2005), pp. 63-81.

Peter Chen, Guoli Ding, "A Note on the Complexity of Rooted Tree and Hierarchies with Possible Applications to Organization Design and System Architecture", Transactions on Applied Mathematics, Accepted

Min Song, Il-Yeol Song, and Peter Chen, "Design and Development of a Cross Search Engine for Multiple Heterogeneous Databases Using UML and Design Patterns", International Journal of Information System Frontiers, p. 77, vol. 6, (2004).

Ding, G., and Chen, P.P., "Unavoidable Double-Connected Large Graphs", Discrete Mathematics, Volume 28 Issues 1-3, (6 April 2004), pp. 1-12.

3. 2. Books or Other One-time Publications
Peter Chen, "Toward A Structured Icon Design Methodology", (2003). Conference Proceedings, Published Bibliography: Proceedings of IEEE Conference on Multimedia Software Engineering (MSE03)

Peter P. Chen, "Architecture for Information Assurance Decision Support based on Knowledge Intensive Mult agent Systems", (2003). Conference Proceedings, Published Bibliography: Proc. IEEE International Conference on Integration of Knowledge Intensive Multi-Agent Systems

Jianhua Chen, et. al., "Induction and Inference with Fuzzy Rules in Textual Information Retrieval", (2004). Bo Chapter, Published Editor(s): E. Triantaphillou and G. Felici Collection: Data Mining and Knowledge Discover Techniques based on Rule Induction Techniques Bibliography: Kluwer Academic Publishers

Peter P. Chen, "A Note on the Complexity of Rooted Tree and Hierarchies with Possible Applications to Organization Design and System Architecture", (2005). Conference Proceedings, Accepted Bibliography: Proceedings of Conference on applied Mathematics

L. Moscovich and Jianhua Chen, "Supervised Hidden Markov Model Learning using the State Distribution Oracle", ( ). Conference Proceedings, Submitted Bibliography: Conference on Machine Learning

J. Chen, P. Chen, G. Ding, R. Lax, "A New Method of Learning Pseudo-Boolean Function with Applications ir Terrorist Profiling and Predictions", (2004). Conference Proceedgins, Published Bibliography: IEEE Conferen on Cybernetics

Nigel Gwee and Peter Chen, "THE WHOLE GREATER THAN THE SUM OF ITS PARTS: COMBINING THE STRENGTHS OF HEURISTIC OPTIMIZATION ALGORITHMS ", (2004). Conference Proceedings, Publishec Bibliography: IEEE Conference on Cybernetics

7. Interactions

The PI and several students organized the system architecture workshop held in New Orleans in January 2004, which provided a forum for researchers and practitioners to interact with each others. Besides this workshop, the PI also attended several conferences and workshops and exchanged ideas with other researchers and practitioners.

8. New discoveries, inventions, or patent disclosures

(None)

9. Honors and Awards

9.1. Before this grant was awarded

- Listed in **Who's Who in America**, 1989-now
- Listed in **Who's Who in the World**, 1990-now.
- **IEEE Harry Goode Award**, IEEE Computer Society, 2002. Previous recipients include pioneers in computer (**Aiken, Stibitz, Zuse, Eckert, Mauchly,** and **Wilkes**), magnetic memory (**Forrester**), semiconductor and INTEL Corp. (**Moore** and **Noyce**), and IBM compatible mainframes (**Amdahl**), not to mention other very distinguished scientists.
- **Recognized as one of 16 "Software Pioneers,"** at the **Software Pioneers Conference**, June 28/29, 2001, Bonn, Germany. Other software pioneers include: **Fred Brooks, E. Dijkstra, T. Hoare, D. Parnas, N. Wirth, Ole-Johan Dahl, K. Nyaard, and Alan Kay**. Some of these Software Pioneers are either National Medal of Technology winners, ACM Turing Award winners, or IEEE Harry Goode Award winners.
- **Information Technology Award**, Data Admin. Mgmt Association (NY), 1990.
- **Year 2000 Achievement Award**, DAMA International, 2000. Dr. **E. F. Codd** (the inventor of the Relational model and an ACM Turing Award winner) was the recipient of this award in 2001.
- **Inductee, Data Management Hall of Fame**, 2000.
- **Stevens Award in Software Method Innovation**, 2001.
- **Fellow, IEEE** (Institute of Electrical and Electronic Engineers), elected 1987.
- **Fellow, ACM** (Association of Computing Machinery), elected 1997.
- **Fellow, AAAS** (American Association of Advancement of Sciences), Elected 1999.
- **Member, European Academy of Sciences**, Elected 2002.
- **Distinguished Faculty Award**, LSU, 2005.
- **Invited Expert**, several working groups, **World Wide Web Consortium (W3C)**, 1999 - now.
- IEEE Computer Society **Certification of Appreciation**, 1984.
- **Career Development Award**, UCLA, 1979; **Harvard University Fellowship**, 1969.
- **First Place**, National Competition of Studying-Abroad Scholarships, Taiwan, 1969.

9. 2. After the time this grant was awarded

- **ACM/AAAI Allen Newell Award**, 2003. The past recipients are: **Brooks** (winner of National Medal of Technology and Turing Award), **Lederberg** (winner of **Nobel Prize** and National Medal of Science), **Mead** (winner of National Medal of Technology), **Amarel, Leveson, Zadeh**, and **Bajcsy**.
- **2004 Pan Wen-Yuan Outstanding Research Award**, Taiwan (each year given to one individual in the high tech fields and residing outside of Taiwan and China). The 2003 Winner was **Andrew C.C. Yao** (an ACM Turing Award winner).
- **Member, Advisory Board, National Science Foundation, Computer and Information Sciences Directorate (NSF/CISE)**, July 2004 - Now.
- **Member, Air Force Scientific Advisory Board (AF-SAB)**, 2005-Now.
    - New Orleans System Architecture Workshop Held January 2004